240

FW BELL INC.
ELECTRONIC DESIGN • DEVELOPMENT • MANUFACTURING
COLUMBUS, OHIO

SPECIFICATIONS

RANGES:

12 Ranges is Gauss, All ranges are full scale.

.1	3	100	3,000
.3	10	300	10,000
1	30	1,000	30,000

B MEASUREMENT RESOLUTION:

1 part in 100 (1% full scale, using panel meter) to 0.1% using external readout, or 1 milligauss, maximum.

$\triangle$B INCREMENTAL RESOLUTION:

1 part in 10,000 (Max.) of nominal field, over the range 10G to 10 KG.

SCALE EXPANSION:

100 times.

ZERO SUPPRESSION:

To approximately 14 KG.

B MEASUREMENT ACCURACY:

1% of full scale to 10 KG. Calibration curve available for 10 KG to 30 KG range. Accuracy at reference points depends on accuracy of reference magnets used, 0.5% magnets available.

$\triangle$B MEASUREMENT ACCURACY:

1% to 5% of full scale value of range used, depending on amount of scale expansion and ranges used.

AMPLIFIER-DEMODULATOR SYSTEM LINEARITY:

0.2% of full scale.

OUTPUT JACKS (Front Panel):

(a) Voltage, -2 volts plus or minus 10% for a full scale signal.
(b) Source resistance, 50 K ohms.
(c) Frequency response, zero to 60 cps, (zero to 400 cps with filter, 300 MV output) See curve sheet.

AUXILIARY OUTPUT TERMINALS (Rear Panel):

(a) Voltage, adjustable from -2 V to -5 V d-c for a full scale signal.
(b) Source resistance 150 ohms.
(c) Frequency response, see curve sheet, 10 milli-sec response to an input full scale step function.

POWER INPUT REQUIREMENTS:

117/234 volts rms. plus or minus 10% - 50-60 cycles 50 watts

DIMENSIONS:

12" wide, 14-1/2" deep, overall height 7"

WEIGHT:

Net 20 lbs., Shipping 24 lbs.

G E N E R A L

The Model 240 Gaussmeter is a precision magnetic flux measuring instrument and has two outstanding capabilities.

Direct measurements of AC or DC fields from 100 milligauss to 30,000 gauss can be made with high accuracy and stability. This information can be read out directly on the meter in gauss and is available at output jacks for external readout instruments.

The outstanding capability of the Model 240 is in observing small changes or increments in magnetic flux density. By means of a controlled feedback system, the Model 240 is capable of magnifying a small change in field strength by a factor of 100. That is, the probe may be inserted into a large field and by increasing the feedback voltage and sensitivity of the Model 240, a field change of 1 part in 1000 is easily readable. The change in flux density may be made by a modulation of the field or displacement of the probe in a field where a gradient exists.

C O N T R O L S

FRONT PANEL

POWER

This toggle switch turns on the primary power to the unit.

FIELD REVERSE

This toggle switch provides for an up-scale reading when the field direction is reversed.

RANGE SWITCH

This switch selects the full scale meter range in Gauss when the instrument is used as a direct reading Gaussmeter. When used as an incremental instrument, the switch position indicates the full-scale range of the ∠∠ Gauss increment, or change in magnetic field strength.

PROBE ZERO ADJUSTMENT (Gray Knobs)

These three controls marked COARSE, INTERMEDIATE and FINE are used to balance each individual probe.

FEEDBACK (Black Knobs)

The FEEDBACK-INCREASE switch and the two controls marked COARSE and FINE are used to vary the feedback voltage which makes it possible to measure incremental field changes.

OPERATING AND SERVICING MANUAL

MODEL 240

GAUSSMETER

This manual is temporary. Final manual
will be mailed to you as soon as completed.

F. W. BELL, INC.
1356 Norton Avenue
Columbus 12, Ohio

OUTPUT JACKS

These are detector output jacks providing a negative 2 volts output for a full-scale reading on the meter with a 50,000 ohm source impedance. The voltage is accurately proportional to magnetic field strength and is usable from D.C. to 60 cps. (400 cps with filter installed)

REAR PANEL

CONTROL CURRENT

With Switch 3 in the up position, the front panel meter reads control current and R9 should be adjusted to read full scale.

CAL

With S4 in the up position, R52 is used to calibrate the amplifier gain for the particular probe in use.

DETECTOR BAL.

This is a factory adjustment which is used to zero the meter under zero signal conditions.

AUXILIARY OUTPUT ZERO

This control is adjusted for zero voltage at AUX OUTPUT under zero signal conditions.

AUXILIARY OUTPUT CAL.

This control adjusts the voltage at the AUX OUTPUT terminals from -2 to -5 volts full-scale. This is to permit optimum matching to external load requirements.

RELAY BIAS

This is a factory adjustment and sets the trigger point for the overload light relay.

AUX OUTPUT

These terminals provide a negative voltage of -2 to -5 volts D.C. full-scale, with a source impedance of 150 ohms. This voltage is accurately field proportional and is completely isolated from the front panel output jacks voltage, except for common chassis ground.

METER

These terminals provide a means of externally short-circuiting the panel meter when the instrument is used as a differential instrument.

POWER

The power cable supplied has three conductors and is terminated in a three-prong plug recommended by the National Electrical Manufacturers' Association. The round pin is connected to the chassis and grounds the instrument when used with the appropriate receptacle. An adapter may be used for connection to a standard two-contact receptacle. The ground is brought out of the adapter by means of a short wire which should be connected to a suitable ground for protection of operating personnel. Only when a ground is supplied by associated equipment should this ground be unused to prevent common ground currents.

The Model 240 is normally wired for operation from a 117 volt, 50-60 cps power source. To convert it for 234 volt 50-60 cps operation the dual primary of the power transformer is changed from parallel to series connection. Refer to the schematic diagram for details. When converting from 117 volt to 234 volt operation, replace the 1 ampere slow-blow fuse with a 1/2 ampere slow-blow fuse.

OPERATING INSTRUCTIONS

PROBE HANDLING

CAUTION

The sensing elements used in the YA-247 probes are extremely thin and fragile and can easily be permanently damaged. Special care should be exercised in handling the transverse probe, YA-247, which allows exposure of the thin sensing element for measurements in narrow gaps. To expose the element, rotate the outer protective tube counter-clockwise (about 30 degrees). This releases the safety catch and allows the tube to be pushed back into the handle. Always restore the outer tube to the protective position when not actually making narrow gap measurements. The safety catch will automatically engage when the tube is pulled out to its extreme position and released. Axial probes, such as the YA-248, are not as fragile as the transverse probes and have no protective tube.

The sensing element used in all probes is strain sensitive and no forces should be applied directly against it during measurement. Also, it should be protected from temperature shock, such as touching against hot or cold objects. High temperature environments, rapid thermal changes, or high velocity air flow over the element can also result in apparent drift of the zero setting on the lower ranges and should be avoided.

No attempt should be made by the user to repair or modify the probe assembly in any way. The probe cable is of special design and its terminations in the cable plug and probe handle are very precisely adjusted to cancel out quadrature voltages which would cause overload and nonlinear operation on

the lower ranges. If needed, probes with longer cables can be obtained on special order.

APPLYING POWER

Before turning the instrument on, connect a probe to the input receptacle (attach securely) and turn the RANGE selector to the 30K position. Turn FEEDBACK switch to the OFF position. Plug the power cable into a source of specified voltage and frequency.

Turn the power switch on and allow five minutes for preliminary warm-up. Complete stability is reached in about one hour.

PROBE BALANCE ADJUSTMENT

TRIMMER POTENTIOMETER ADJUSTMENT

If the instrument has not been previously adjusted for the particular probe installed, some adjustment of the coarse trimmer will probably be required. First set the INTERMEDIATE control to approximately mid-range. Rotate the RANGE selector counter-clockwise until a reading is obtained on the meter (if down-scale reading occurs, throw REVERSE switch to opposite position). Adjust trimmer to reduce reading toward zero while continually reducing the range setting until near zero reading is obtained on the 30 gauss range. DO NOT ADJUST COARSE POTENTIOMETER ON LOWER RANGES.

ZERO ADJUSTMENT

The INTERMEDIATE control will not have adequate range to provide adjustment to zero and about one gauss or more each side of zero. For precise zeroing on the lower ranges use the FINE control as needed. The probe should be in a zero gauss chamber to obtain a true zero.

The above zeroing procedure can be carried out quite rapidly without "banging" the meter pointer in the process. Although meter protection is designed into the circuitry, needless "banging" of the pointer can result in meter damage and should be avoided.

NOTE: It is important to note that this instrument has high sensitivity and that the earth's magnetic field will read off-scale on the low ranges.

CALIBRATION PROCEDURE

When changing probes, it is necessary to repeat the probe balance adjustment procedure (above) and recalibrate the instrument for that particular probe. The instrument should be turned on, with probe connected, at least one hour before calibrating.

There are two steps involved in calibrating the Model 240:

A - Adjust control current
B - Adjust amplifier gain

A. ADJUST CONTROL CURRENT

After connecting and zeroing the probe, set the rear panel lever switch S3 in the CONTROL CURRENT ADJUST position. Loosen the lock nut on R9 (adjacent to S3) and adjust for exactly full scale deflection on meter. Tighten lock nut and restore S3 to normal position.

B. ADJUST AMPLIFIER GAIN

After adjusting the control current the amplifier gain must be adjusted in accordance with the sensitivity of the particular probe in use, using one of the following methods:

1. Calibration against a reference magnet
2. Calibration against probe CAL constant

For best accuracy, calibration using a reference magnet is recommended. Calibration against the probe CAL constant is a transfer method giving slightly reduced accuracy, but is somewhat easier to accomplish and often more convenient than using a reference magnet.

1. CALIBRATION AGAINST A REFERENCE MAGNET

If the reference magnet used is below 100 gauss, the zero procedure must be accomplished with the probe inside a shielded chamber, such as the Bell YA-111 zero gauss chamber. Next, set the RANGE switch to proper position for the flux density rating of the reference magnet. Insert the probe in the magnet and position for maximum meter reading. Then adjust the CAL control, R52 on rear panel, to make the meter reading agree with the value of the reference magnet.

2. CALIBRATION AGAINST PROBE CAL CONSTANT

Each probe has been checked against calibrated magnets under standard test conditions and assigned a sensitivity constant. To transfer this value into the instrument, first set the RANGE switch to the 30K-CAL position. Next operate the CAL switch S4 on the rear panel and note the meter reading on the 0-1 scale. Adjust the CAL potentiometer R52 to make the meter read the value of the CAL CONSTANT indicated on the probe handle. Release S4 and the instrument is ready for use.

FIELD STRENGTH MEASUREMENTS

NOTE: The FEEDBACK switch must be in the off position for all absolute measurements.

LOW LEVEL MEASUREMENTS

IMPORTANT

The Model 240 is an extremely sensitive instrument and its use on the lower ranges requires that certain precautions be observed.

The earth's magnetic field will give about half-scale meter reading on the 1 gauss range in the U.S.A. (depending on the position of the sensing element and the setting of the ZERO controls). This obviously can cause increasingly greater errors below the 100 gauss range as well as considerable overload of the instrument on the .3 and .1 gauss ranges. For this reason, the effects of the earth's field (and any other fields that may be present) must be eliminated to obtain satisfactory readings at low levels.

To obtain "absolute" or "true" zero requires adequate shielding of the probe. Shielding can be accomplished by the use of high-permeability material such as mu-metal. The YA-111 ZERO GAUSS CHAMBER provides more than 80 db of attenuation in fields up to 300 gauss. This is more than adequate to reduce the earth's field below the sensitivity of the Model 240 GAUSSMETER.

For many low-level measurements it will not be necessary to obtain "absolute" zero but will be sufficient to reduce the effects of the earth's field and any other extraneous fields by one of the following methods:

1. Maintain the probe in a fixed relationship to extraneous fields and use the ZERO controls to "cancel out" their effect.

2. Orient the probe to a point midway between peak readings in each direction.

3. Use Helmholtz coils to generate a cancelling field.

For exploratory work at low flux densities it is usually satisfactory to mount the probe in a clamp, zero out extraneous fields, and then move the device under test in the vicinity of the sensing element.

MEASURING DC FIELDS

In measuring steady DC fields the probe is oriented in the field or gap to obtain the highest meter reading. For best accuracy always select the range which gives the highest meter deflection.

Transverse probes measure the component of flux density, B, which is normal to the plane of the sensing element. Axial probes measure the component of B which is parallel to the axis of the probe. Careful positioning of the probe relative to the flux lines is necessary in order to obtain the most accurate reading. If a down-scale reading is obtained, either throw the REVERSE switch on the Model 240 or reverse the position of the probe in the field.

NOTE: The AUX OUTPUT terminals on the rear panel provide a negative voltage from -2 to -5 volts for a full scale reading of the meter. The AUXILIARY OUTPUT CAL adjusts this voltage to calibrate an external readout

device. The internal source resistance is 150 ohms. The AUX OUTPUT ZERO (rear adjustment) is affected slightly by the AUX CAL adjustment and re-zeroing may be necessary under no signal conditions.

MEASURING AC FIELDS

The Model 240 can be used to observe and measure AC fields by using a suitable external indicator connected to the front panel output jacks. The frequency response depends on the internal filter used in the Model 240. With the standard filter the response is down approximately 6 db at 60 cps. On special order a 400 cps filter, Bell YA-129, is available which will permit use of the Model 240 up to 400 cps. This filter mounts in holes already provided inside the instrument. The AUX OUTPUT terminals on the rear are also suitable for AC measurements. See curve sheet.

An oscilloscope with DC response can be quickly calibrated to measure AC fields directly. An oscilloscope graticule with ten major vertical devisions is very helpful. The oscilloscope is calibrated as follows:

1. Connect the Model 240 output jacks on the front panel to the oscilloscope vertical DC point.

2. Zero the Model 240 on the 1 gauss range and center the oscilloscope trace on the screen.

3. Adjust the zero controls for full scale meter reading, and the oscilloscope gain to move the trace to the bottom graticule line.

4. Recheck the zero and full scale settings described in 2. and 3. above. The oscilloscope is now calibrated so that full beam deflection corresponds to full scale (peak-to-peak value) of flux density. This calibration applies to any range on the gaussmeter.

5. Set rear panel switch S3 in the CONTROL CURRENT ADJUST position. This removes the meter from the output circuit to prevent it from influencing response and from unnecessary meter pointer vibration caused by low frequency signals.

When reading AC fields the steady field (DC) components should be minimized in order to avoid amplifier overload. This will be accomplished if the oscilloscope trace is kept in view by adjusting the Model 240 ZERO controls or by probe positioning and NOT by adjusting oscilloscope positioning controls.

NOTE: Maximum usable AC level is less than the full-scale peak-to-peak level used for calibration above. It is: Front panel output jacks .5 V rms @ 60 cps; AUX OUTPUT terminals .8 V rms @ 60 cps.

If desired, an AC VTVM can be used along with the oscilloscope. A recorder having suitable frequency response and sensitivity can be used in place of the oscilloscope, using the same method for calibration.

INCREMENTAL MEASUREMENTS

Incremental operation of the Model 240 Gaussmeter is obtained by the method

of "zero suppression" and "scale expansion". Zero suppression is accomplished by introducing a feedback signal generated within the Model 240 to buck out the signal due to the field to be measured. The FEEDBACK INCREASE switch will introduce a reverse (downscale) meter deflection.

Scale expansion results when the sensitivity is increased by switching to lower gauss ranges. Thus the Model 240 is direct-reading in $\triangle B$ or flux changes.

The feedback method can be used over the range of 10 gauss of slightly less, to approximately 14 KG. Fields below 10 gauss can be read incrementally by off-set of the probe zero controls.

The feedback signal, being the internally generated, can "zero out" steady or D.C. fields only. The remaining incremental signals may vary at any rate from zero to 60 cps. (400 cps if equipped with filter) in accordance with the response plot shown on curve sheet. If the incremental signal is a slow change, it will be read on the panel meter. If it is AC, the readout will be as described for AC fields.

The incremental feature does not increase the absolute accuracy of gauss measurement, but it permits highly precision comparison readings to be made (to a standard field, for example) with comparison accuracies up to 1 part in 10,000 (0.01%). Due to the high stability of the instrument, this precision can be retained as an absolute accuracy for relatively long periods of time with periodic reference to the standard. Actual time depends on the stability of measurement conditions - temperature of the probe, line voltage, etc.

INCREMENTAL OPERATION

The calibrating procedure and probe balance adjustments described earlier must be carried out. DO NOT CHANGE the probe zero controls (gray knobs) after this adjustment.

Place the probe in the field to be measured, using a suitable holding fixture. Rigid probe mounting is essential since the slightest motion may cause erratic readings. Set the range switch to give the highest reading on the meter.

Now suppress the zero by advancing the FEEDBACK-INCREASE switch until the meter reads approximately zero. Bring the meter to zero using the COARSE FEEDBACK knob. Too much feedback signal will result in below-zero off-scale reading. Reducing the amount of feedback will correct this - DO NOT THROW THE REVERSE SWITCH.

Next expand the scale by increasing sensitivity, rotate the range switch conter-clockwise to lower gauss ranges. Keep the meter on scale by carefully adjusting the black coarse and fine feedback controls (DO NOT TURN THE GRAY ZERO KNOBS). The maximum scale expansion to be used is 100X or 4 steps counter-clockwise on the gauss range switch. The range switch now indicates the full-scale width of the $\triangle B$ increment, in gauss. The reference for this increment can be placed anywhere on scale by adjustment of the black feedback knobs, keeping in mind that meter readings are changes

in flux rather than absolute flux density.

The OVERLOAD indicator lamp will light if too much expansion is used, or if there are excessive noise or quadrature signals overloading the amplifier. Reading errors will occur if this light goes on at any point over the range in use (i.e. as the meter varies over the full meter scale). To avoid errors, switch to a lower range, since overload can occur even when the meter indicates on scale.

If the change in flux becomes greater than the $\triangle$ B range selected, and the meter goes off-scale, switch to a higher gauss range, or adjust the feedback to keep the meter on scale.

EXAMPLE OF INCREMENTAL OPERATION

1. Probe is placed in a 1 KG field (1 KG range).

2. Increase feedback to obtain zero reading.

3. Range switch stepped down to 10 gauss range (100X expansion).

4. Feedback adjusted for center-scale reading on 10 gauss range.

5. Increase the field from 1000 gauss to 1005 gauss.

6. The meter will indicate to full-scale, showing an increase of 5 gauss. ($\triangle$B equals plus 5 gauss)

7. Each minor division on the 10 gauss range is 0.1 gauss. A change of 1 division is therefore a change of 1 part in 10,000 or 0.01% of the 1 KG field. This is the limit of resolution using the built-in panel meter.

Minor fluctuations in a strong field caused by ripple, or other recurrent modulating signals, may be studied in detail by observing on external instrumentation such as a cathode-ray oscilloscope, recording oscillograph, V.T.V.M., etc. connected to the front panel output jacks.

The AUXILIARY OUTPUT terminals on the rear can be used to read slow changes such as gradients or step function changes. They are particularly suitable for supplying a signal to external relays or other control equipment because they provide:

1. A D.C. output voltage or current accurately proportional (1/2% linearity) to field strength B; or $\triangle$B incremental changes.

2. The output can be adjusted using the AUX OUTPUT CAL control to assist in calibrating to external equipment

3. Source impedance is 150 ohms, resistive, giving a full-scale short-circuit current of 13 ma to 33 ma.

4. Full scale step-function response is 20 milli-sec to within 10% of final value.

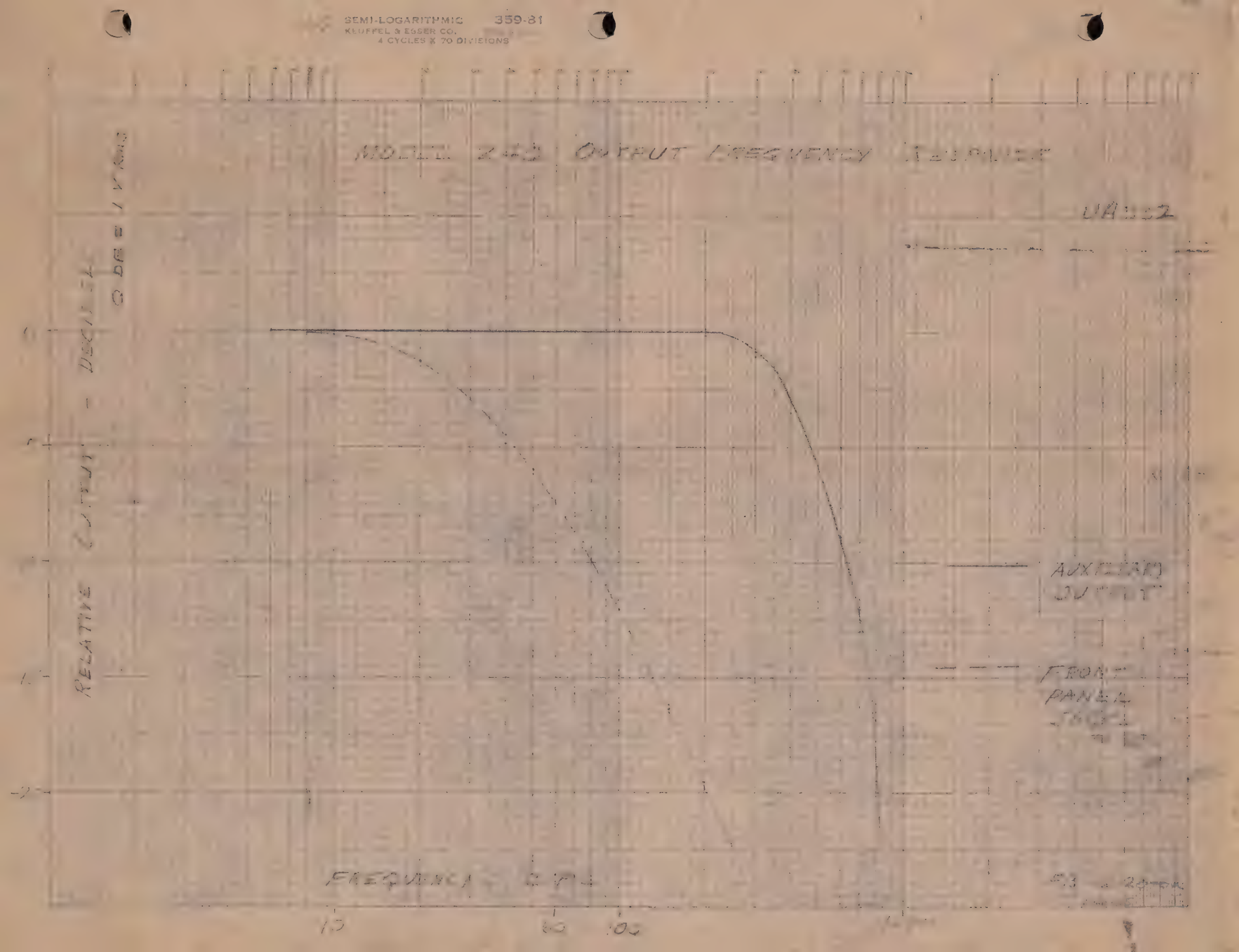
5. Meter terminals are provided for external short-circuiting of the meter for applications where off-scale readings occur between test intervals.

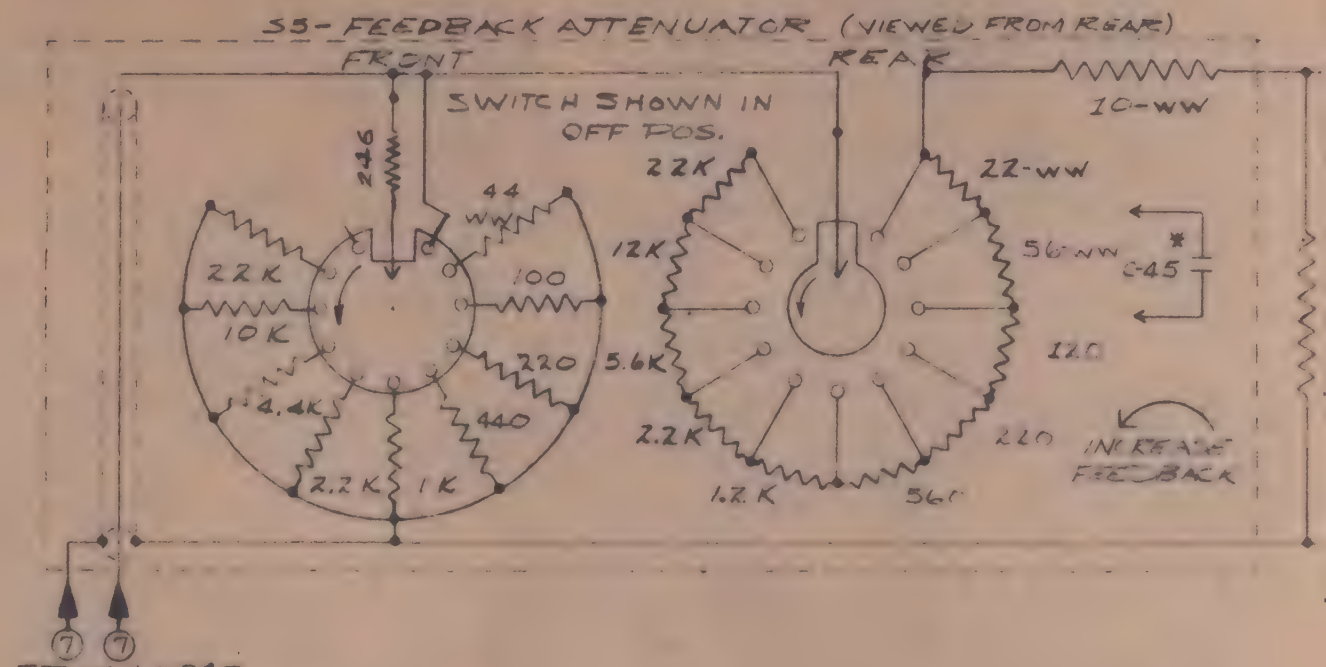
The Model 240 can therefore easily be integrated into an automated production test requiring accurate analog or GO, NO-GO indications such as for grading, sorting and limit rejection.

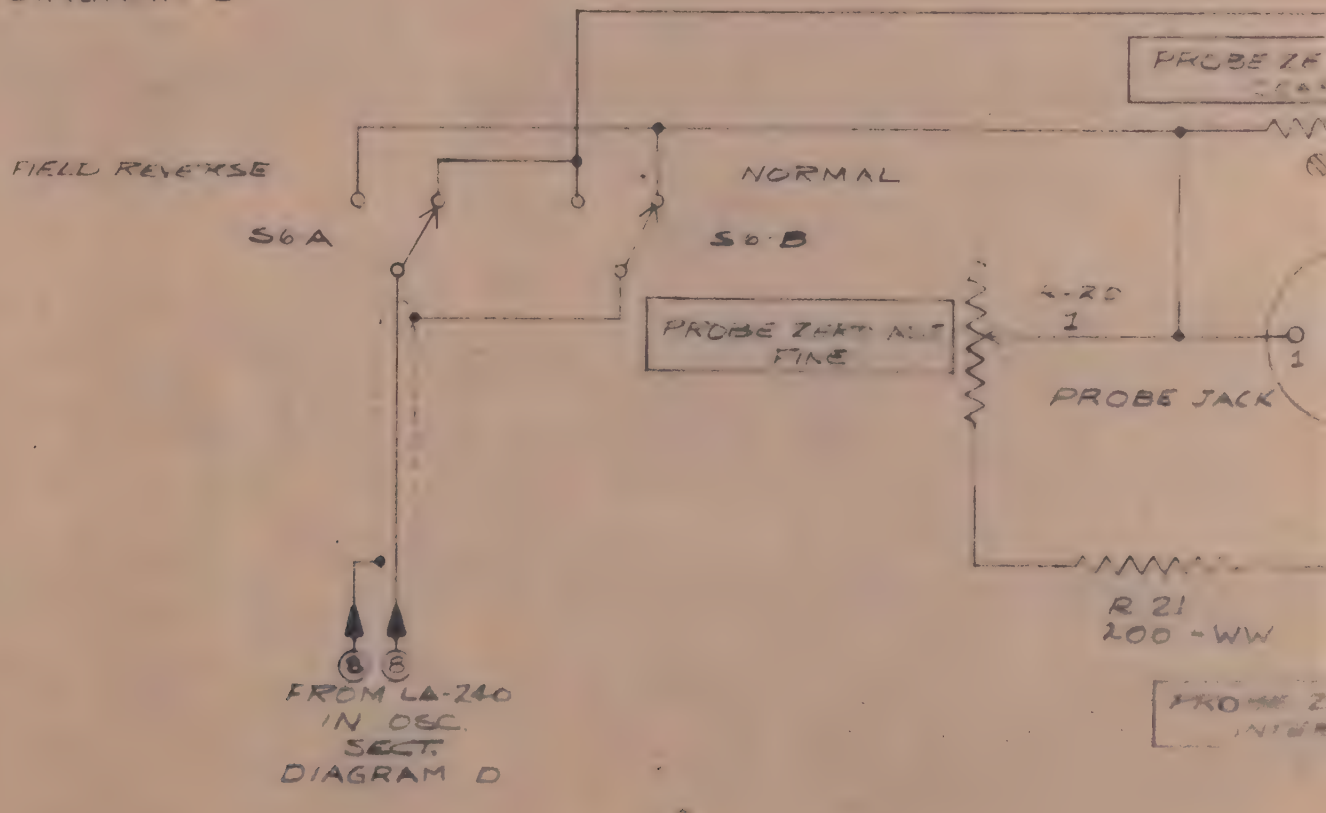
Routine production inspection testing can be done using a reference field for periodic calibration check, with arrangements for meter short-circuiting when the field drops out in between tests.

Other useful production applications occur in continuous monitoring of small flux variations, such as using premagnetized material (or test pieces) flowing past a test point where minute cracks, material properties, annealing, etc. result in magnetic field variations.

Contact engineers at F. W. Bell, Inc. for assistance in handling special problems. Special probes can be supplied for particular applications.

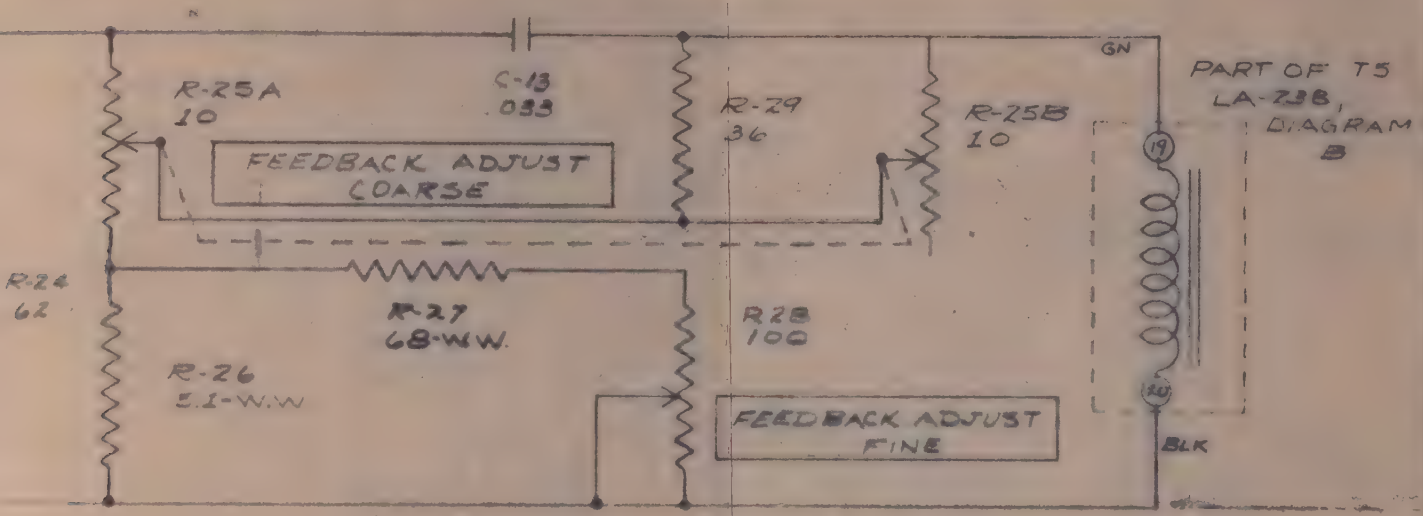

SEMI-LOGARITHMIC 359-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS
MODEL 242 OUTPUT FREQUENCY RESPONSE
UNIT 2
AUXILIARY OUTPUT
FRONT PANEL INPUT
RELATIVE OUTPUT - DECIBELS
0 DB = 1 VOLT
FREQUENCY - C.P.S.
10
100

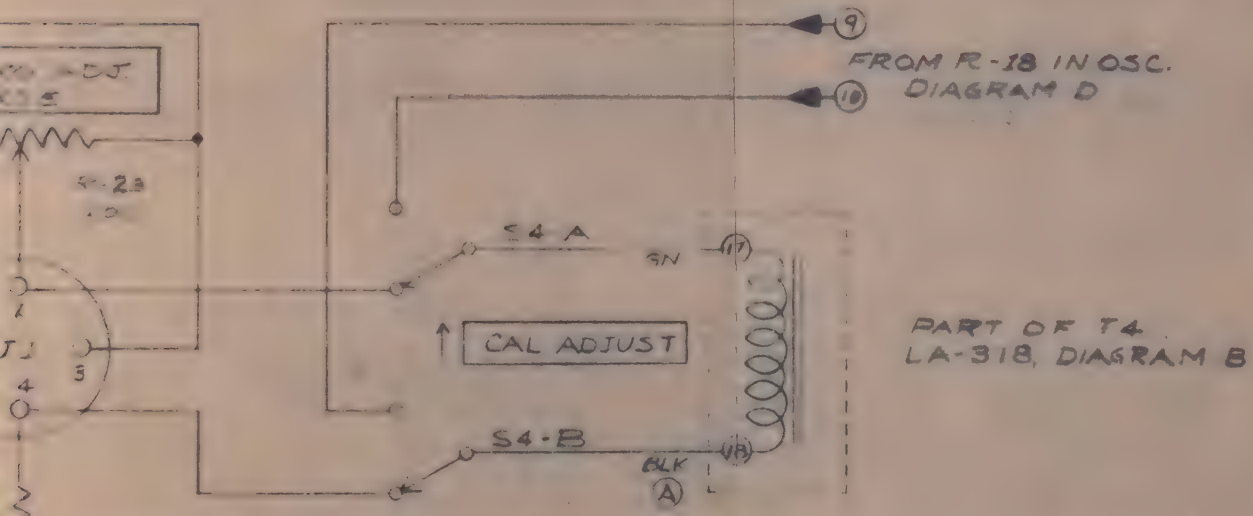




INPUT - DIAGRA
FOR NOTES, SEE DIAG

CHARLES DRUMING CO., INC. NO. 507 KOVEL

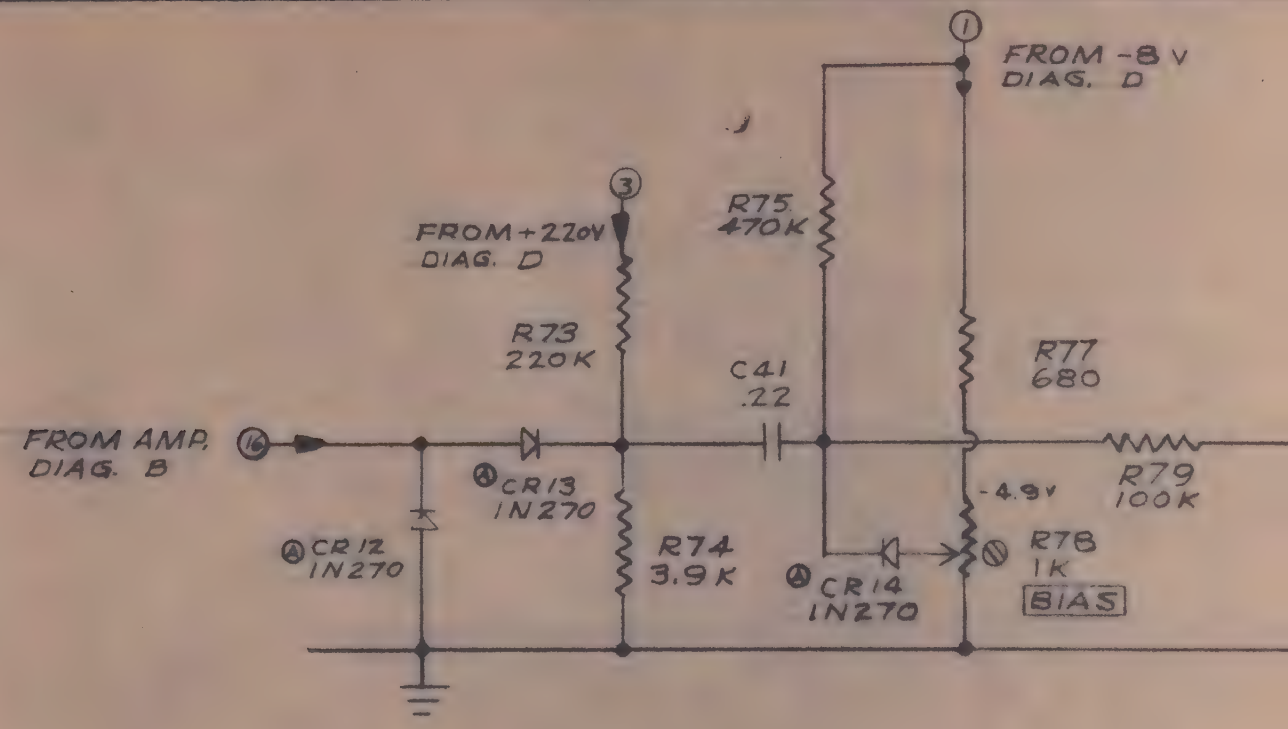


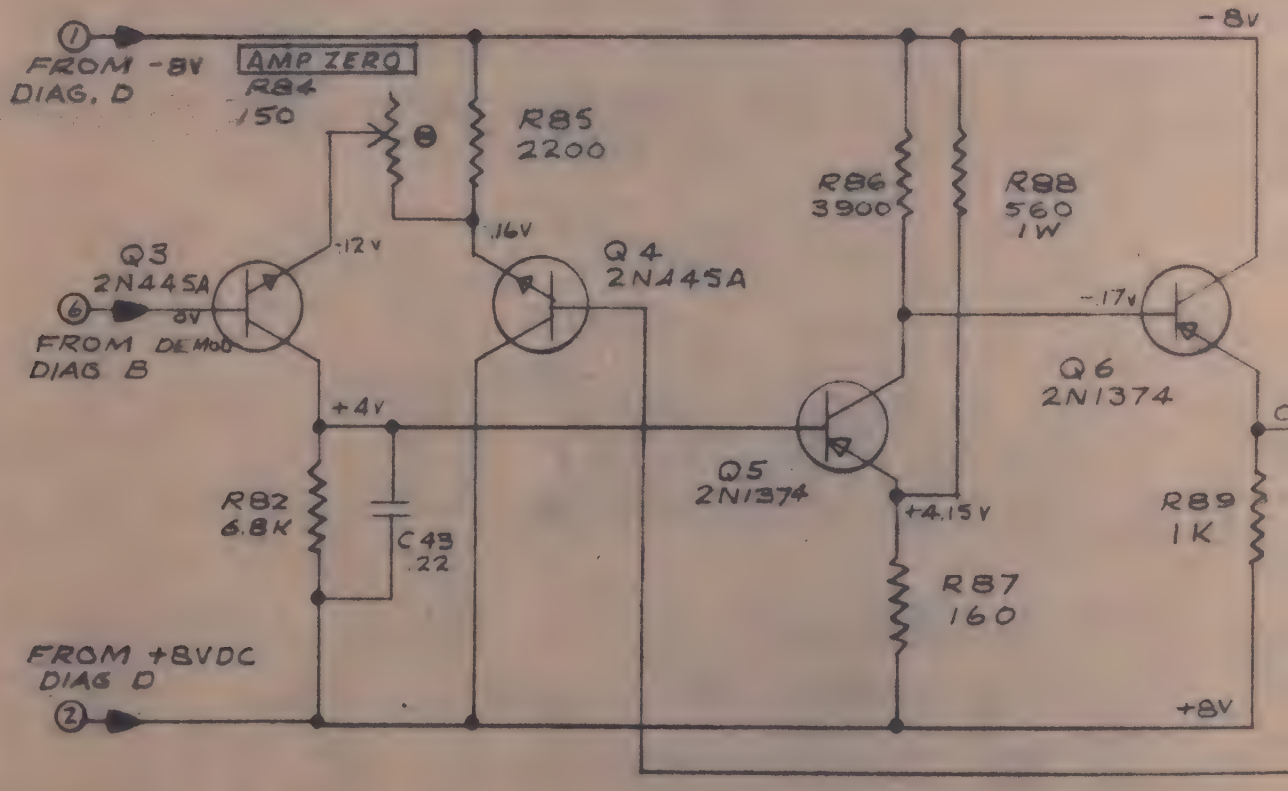


DRAWN R-L-K	SCALE NONE	REVISIONS	DATE
CHECKED		A INTERCHANGED COLORS	6-22-62
APPROVED EOS			
DATE 5-10-62			

TITLE SCHMETIC DIAGRAM OF INPUT & FEEDBACK CIRCUITRY MODEL 240 VOLTMETER

NO. UB-305





OUTPUT - DIAGRAM
FOR NOTES SEE DIAGRAM

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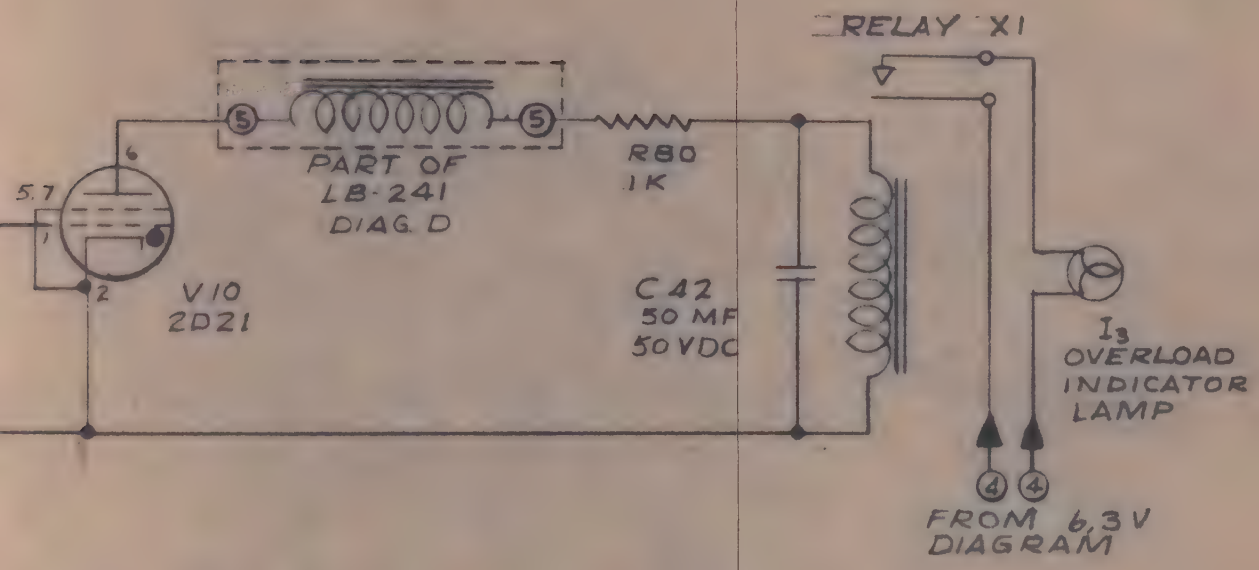
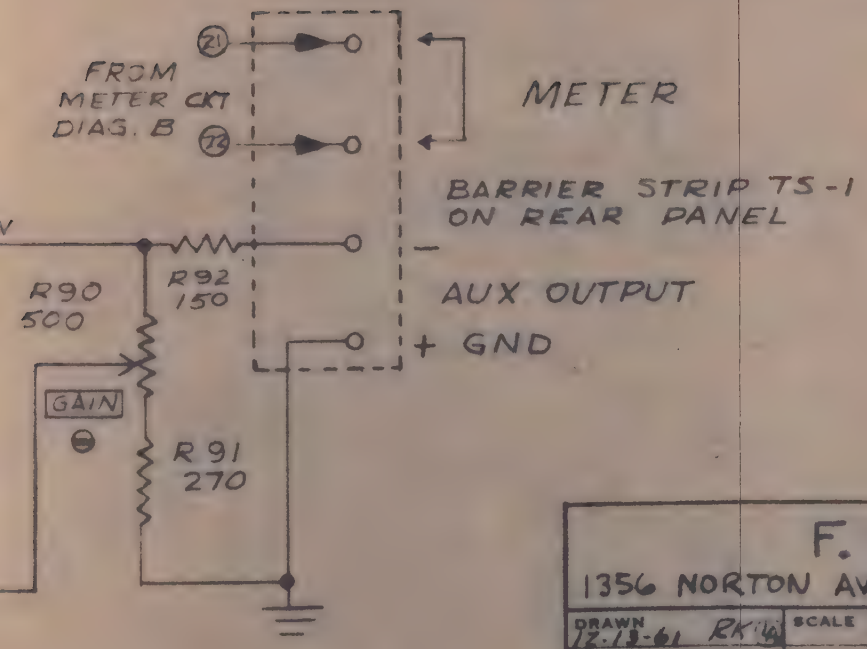
CHARLES BRUNING CO., INC. NO. 207 COVEL





F. W. BELL, INC.

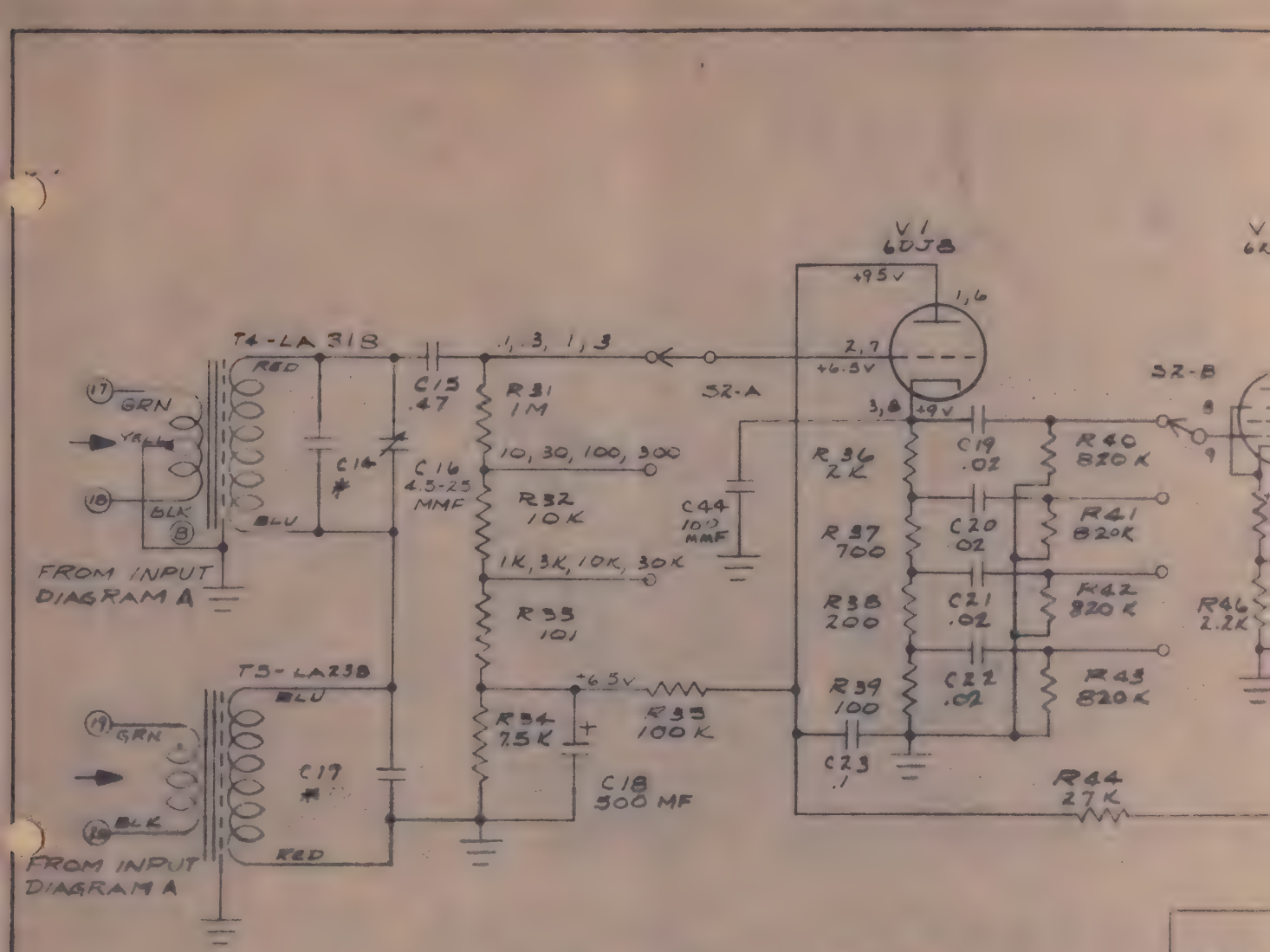
1356 NORTON AVE. COLUMBUS 12, OHIO

DRAWN 12-13-61 RK (A)	SCALE NONE	REVISIONS	DATE
CHECKED E.S.		(A) WAS IN140 EDS	7-18-62
APPROVED EDS			
DATE 5-20-62			

TITLE SCHEMATIC DIAGRAM
OVERLOAD INDICATOR & AUX. AMPLIFIER
MODEL 240 GAUSSMETER

NO. UB306

AGED ORIGINAL -- (A) 8-2-62



NOTES

1. UNLESS OTHERWISE NOTED:
   ALL RESISTANCE IN OHMS
   ALL CAPACITANCE IN MFD.
   K = THOUSAND, M = MILLION

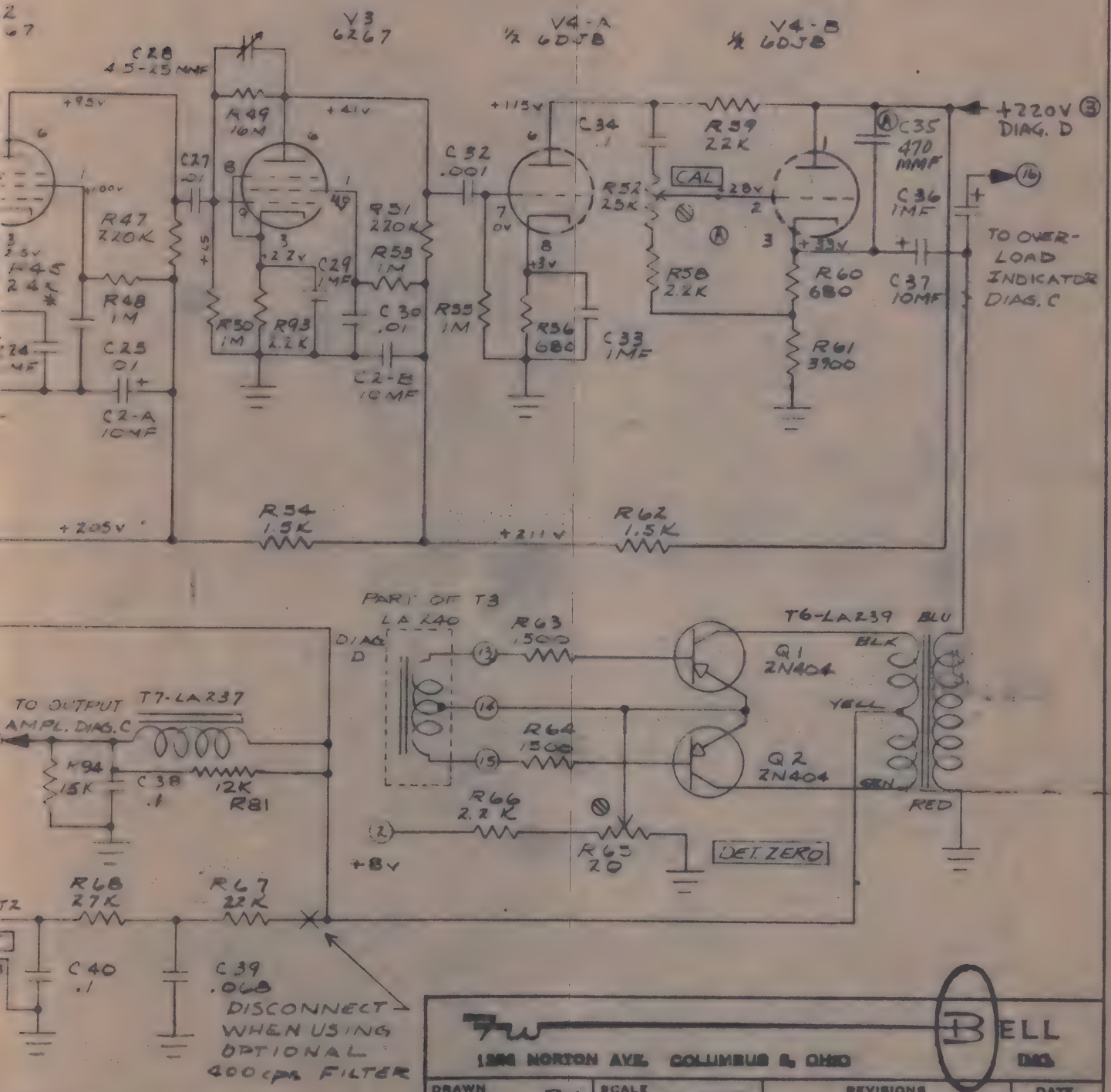
2. * DENOTES VALUE ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE.

3. CONDITIONS OF VOLTAGE MEASUREMENT:
   A. LINE VOLTAGE AT 117/234 VAC 50/60 CPS.
   B. RANGE SWITCH IN 30K POSITION, FEEDBACK SWITCH OFF.
   C. PROBE CONNECTED.
   D. D.C. VOLTAGES MEASURED WITH RESPECT TO CHASSIS USING VTVM.
   E. AC VOLTAGES MEASURED BETWEEN POINTS INDICATED, USING 1000 OHMS/VOLT OR HIGHER A.C. METER.

4. COVERS SERIAL NO. AND ABOVE.

AMPLIFIER – DIAGR

CHARLES BRUNING CO., INC. NO. 197 ROYEL



DETAILS
SC. DIAGRAM-
G. D

AM B

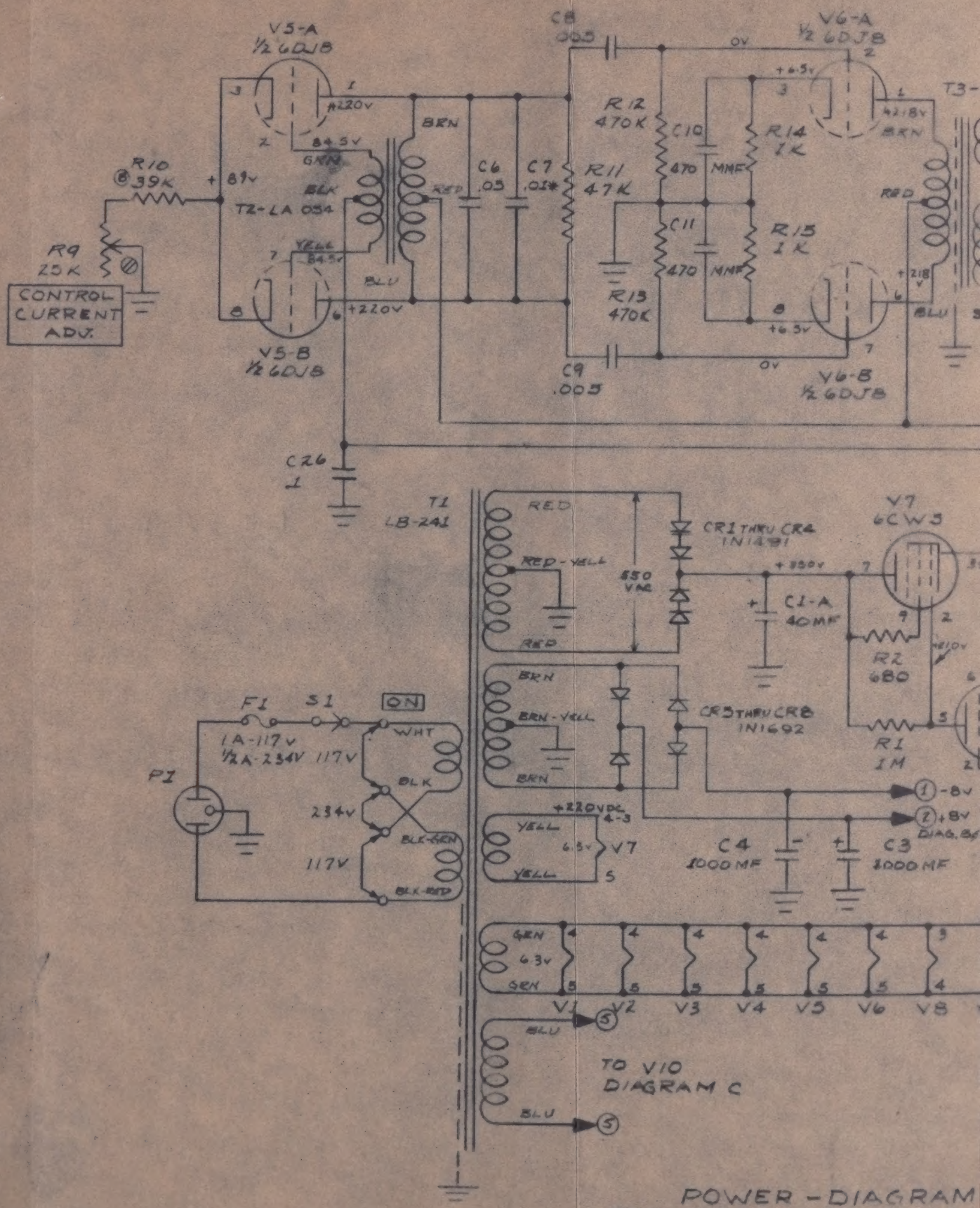
BELL INC.

1356 NORTON AVE. COLUMBUS 8, OHIO

DRAWN	12-9-61 RK	SCALE	NONE	REVISIONS	DATE
CHECKED	EJ			(A) MOVED C35 (A)	6-8-62
APPROVED	EDS			(B) INTERCHANGED COLORS EDS	6-22-62
DATE	5-20-62				

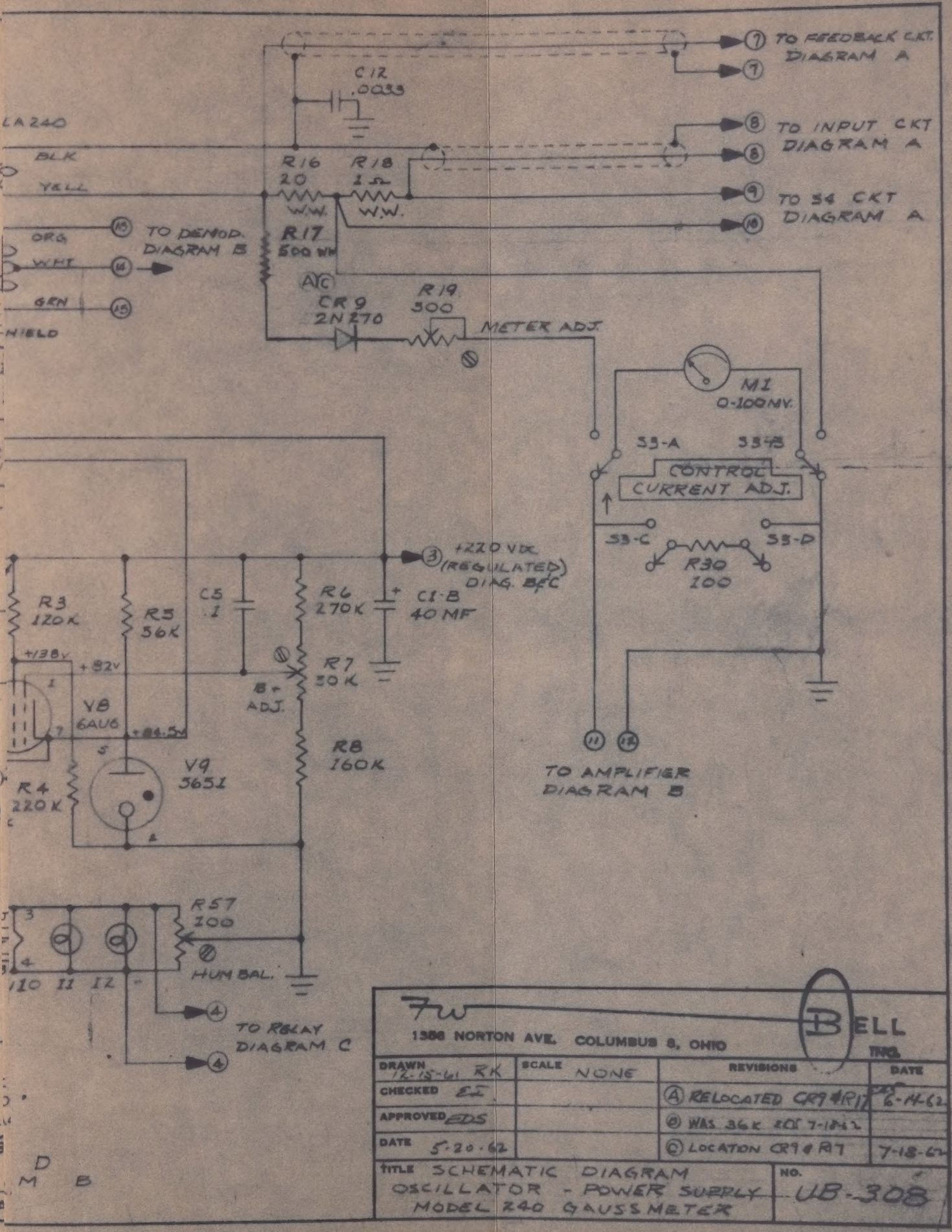
TITLE SCHEMATIC DIAGRAM OF AMPLIFIER AND DEMODULATOR MODEL 240 GAUSSMETER

NO. UB 307



POWER - DIAGRAM
FOR NOTES, SEE DIAGRA

CHARLES DRUMMOND CO., INC. NO. 207 ADVEL



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1386 NORTON AVE. COLUMBUS 8, OHIO

DRAWN 12-15-61 RK	SCALE NONE	REVISIONS	DATE
CHECKED EL		(A) RELOCATED CR9 & R17	6-14-62
APPROVED EDS		(B) WAS 36K 2 OF 7-18-62	
DATE 5-20-62		(C) LOCATION CR9 & R7	7-18-62

TITLE SCHEMATIC DIAGRAM OSCILLATOR - POWER SUPPLY MODEL 240 GAUSSMETER

NO. UB-308

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